HABITAT RELATIONSHIPS OF *GLAUX MARITIMA* IN CENTRAL UTAH

Jack D. Brotherson[1] and Sarah J. Barnes[1]

Abstract.— Thirty-five study sites were established in the meadow communities surrounding Utah Lake in central Utah. The study sites ranged across several community types. *Glaux maritima* was found in all sites but varied as to its ecological importance in these communities. Sixteen soil factors were measured relative to the stands studied. Cover of *Glaux maritima* correlated with parts per million sodium and total soluble salts in the soil. No other factors correlated significantly with the cover of Glaux maritima. *Glaux maritima* occupied only those sites with high levels of moisture throughout the growing season. The high moisture levels came from springs, seeps, elevated water tables, and early seasonal inundation. High levels of Glaux maritima cover corresponded to low numbers of species in the habitat.

Glaux maritima (Sea milkwort) is known in the geological record from organic deposits of Devensian (last glacial) age from England and Europe (Adam 1977). It is a succulent, halophytic forb whose optimal growth occurs in habitats with moderately to highly saline soils. In the northern hemisphere, it is restricted to coastal tidal and inland alkaline marshes and meadowland areas (Hitchcock and Cronquist 1973).

Most of the research on *Glaux maritima* has been done in Europe and has emphasized its physiological and histological characteristics. Rozema and Riphagen (1977) found that the more saline the soil, the more salt was secreted by its salt glands. The structure and function of the salt gland itself was studied in depth by Rozema et al. (1977). Rozema (1975) stated that there was no conclusive evidence to prove that salinity has a stimulating influence on the growth of this species. Carbohydrate concentrations in the hibernacle roots of *G. maritima* were studied by Grandin (1973). Other research on its biology includes salt secretion (Rozema et al. 1981), nitrogen metabolism (Stewart et al. 1973), the effects of sodium chloride and soil water saturation on the development and carbohydrate and mineral content of the plant (Grandin 1981), geographic distribution patterns (Dapper 1969, Rozema 1975, and Toman 1976), population dynamics (Rozema et al. 1978), and soil relationships (Konovov 1978). Little if any has been written on the habitat and community relationships of *Glaux maritima* in North America.

The purpose of this paper is to discuss the habitat and community relationships of *Glaux maritima* in central Utah. An understanding of these factors should be of value to the management of wetland habitats involving this species.

Study Area

The study sites (35) were established in meadows surrounding Utah Lake in Utah County, Utah (Lat. 40°10'N, Long. 11°50'W), where the mean elevation above sea level was 1377 m. Weather information characteristic of the study site is best represented from data taken at the Provo City airport, which lies within the community boundaries being studied. Average temperatures range from 33 C in July, the hottest month, to 3 C in January, the coldest. Precipitation is in the form of both snow and rain, averaging 340 mm annually, with 60% falling during the winter and spring months. The annual precipitation of adjacent mountain ranges averages from 760 to 1270 mm (Morden 1980).

Materials and Methods

Thirty-five study sites were randomly selected from saline meadow communities in the Utah Lake area (Fig. 1). A 10 x 10 m

[1]Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.

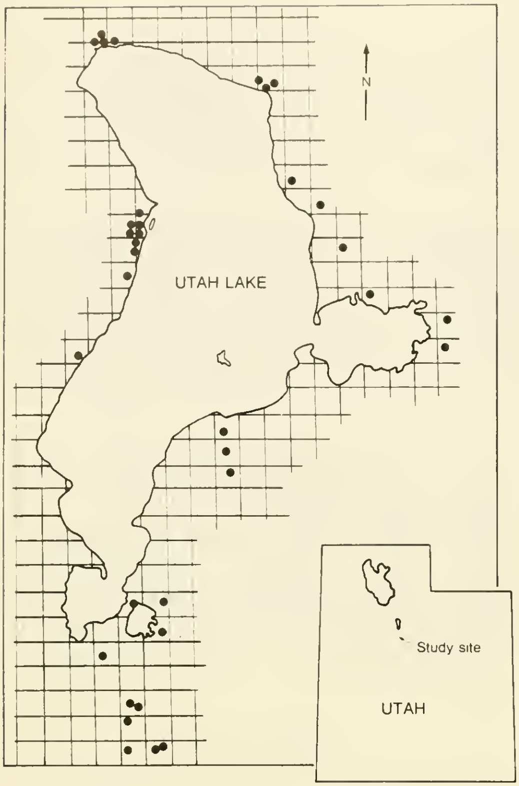

Fig. 1. Map showing the locations of 35 study sites near Utah Lake in central Utah.

study plot (0.01 ha) was established at each site. Study plots were delineated by a cord 40 m long with loops every 10 m for corners. The corners were secured by steel stakes. Each plot was subsampled with twenty 0.25 m^2 quadrats distributed across the surface of the plot in a grid of five evenly spaced transects of four quadrats each. This placement kept the quadrats equal distances from each other and spread them uniformly across the plot.

Total living plant cover, plant cover by life form (i.e., trees, shrubs, subshrubs, perennial forbs, perennial grasses, sedges, rushes, annual grasses, annual forbs, cryptogams), litter, exposed rock, bare soil were ocularly estimated from each quadrat following a procedure suggested by Ostler (1980). Cover for all plant species encountered was also estimated using the cover class categories suggested by Daubenmire (1959). In addition, all species occurring within the study plot but not encountered in the quadrat subsamples were listed and given a percent cover value of 0.01 so they could be included in the overall data analyses.

Three soil samples were taken in each plot (from opposite corners and the center) from the top 20 cm of soil and later combined for laboratory analysis. This depth was considered adequate because Ludwig (1969) in a study of different foothill communities in Utah showed that the surface decimeter of soil when sampled with reference to mineral concentrations yields 80% of the information useful in correlations with plant data. Holmgren and Brewster (1972) also showed in a study of desert shrub communities in western Utah that greater than 50% of the fine roots (those most likely to absorb soil minerals) were found concentrated in the upper 15 cm of the soil profile. With respect to grasslands, Christie (1979) found that the top layer of soil is the region of most active mineral uptake.

The following characteristics were recorded for each plot: elevation (taken from published U.S. Department of Interior Geological Survey 7.5 minute series topographic maps); percent slope; slope position (1 = ridgetop, 2 = midslope, 3 = drainage accumulation area); moisture (1 = dry, 2 = moist, 3 = wet, 4 = seasonally inundated, 5 = submerged); grazing impact (0 = none, 1 = light, 2 = moderate, 3 = heavy).

Soil samples were analyzed for texture (Bouyoucos 1951), pH, soluble salts, mineral composition, and organic matter. Soil reaction was taken with a glass electrode pH meter. Total soluble salts were determined with a Beckman electrical conductivity bridge. A 1:1 soil-water paste (Russel 1948) was used to determine pH and total soluble salts. Soils were extracted with 1.0 neutral normal ammonium acetate for the analysis of calcium, magnesium, potassium, and sodium (Jackson 1958, Hesse 1971, Jones 1973). Zinc, manganese, iron, and copper were extracted from the soils by use of DTPA (diethylenetriamine-penta-aceticacid) extracting agent (Lindsay and Norvell 1969). Individual ion concentrations were determined using a Perkin-Elmer Model 403 atomic absorption spectrophotometer (Isaac and Kerber 1971). Soil phosphorus was extracted by sodium bicarbonate (Olsen et al. 1954). Total nitrogen analysis was made using macro-Kjeldahl procedures (Jackson 1958). Organic matter was determined by total carbon measurement via burning 10 grams of soil sample at 950 C in a LECO medium temperature resistance furnace following methods described by Allison (1965).

Plant nomenclature follows Welsh and Moore (1973) for the dicotyledons and Cronquist et al. (1977) for the monocotyledons. Prevalent species (those most frequently encountered during sampling) of the various plant communities are reported as equal to the average number of species per 0.01 ha sampling area examined (Warner and Harper 1972).

Cluster analysis techniques (Sneath and Sokal 1973) were applied to similarity index values (in percent) computed via the formula: SI = Σ min (XiYi)/Σ max (XiYi) where SI is the similarity index between two study sites: the min (XiYi) represents the sum of the minimum values from the paired relative abundance figures across all species found in stands (XY), and the max (XiYi) represents a similar figure for the maximum values of the same two stands (Ruzicka 1958). Clustering the above indices employed unweighted pair group clustering procedures (Sneath and Sokal 1973). This method computes the average similarity of each unit to the cluster, using arithmetic averages. It is widely used and has been found to introduce less distortion than other methods (Kaesler and Cairns 1972). Using this technique we expected to cluster those stands which were most alike together and thus aid in uncovering relationships existent between them.

Data analysis consisted of computing means, standard deviations, and coefficients of variation for all measured biotic and abiotic variables (Ott 1977). Linear regression analysis (Cochran and Snedecar 1976) was applied to the cover values of *Glaux maritima* in relationship to the associated biotic and abiotic factors in the study sites to determine the degree to which they were associated.

Results and Discussion

A total of 110 species were encountered in 35 stands. Of these 110 species, 14 were considered prevalent species and are shown in Table 1. The majority of these species grow on sites of elevated moisture levels in the soil and are to some degree tolerant of salinity and alkalinity.

To assess the relationships of *Glaux maritima* to the communities in which it occurred, a cluster analysis was performed (Fig. 2). The cluster analysis revealed the separation of the stands into six basic groups, with two stands remaining apart from the rest. These two remaining stands were arbitrarily designated as an independent group, because they do not represent any particular community and are not clustered significantly with the other stands.

The Spike Rush Meadow stands (Group 1; Fig. 2) are situated in areas that are often inundated in early seasons of the year and which have a continual water supply (either from springs, seeps, or elevated levels of ground water throughout the growing season). They are dominated primarily by *Eleocharis palustris* and other sedges, with some contribution from perennial grasses and forbs (Table 2).

The Marsh Edge Meadows (Group 5; Fig. 2) constitute a broadly scattered type occurring around the entire perimeter of the Utah Lake marsh as well as being well developed in areas back from the lake where there is constant water accumulation from springs or runoff. The dominant species of this group is *Scirpus pungens*, with *Distichlis spicata*, *Muhlenbergia asperifolia*, and *Trifolium repens* as subdominants (Table 2). Although these meadows are often subjected to in-

TABLE 1. Prevalent species associated with sites where *Glaux maritima* was found growing.

	Presence (%)	Average Cover (%)	PxC index
Distichlis spicata	77.14	28.12	21.69
Eleocharis palustris	65.71	23.65	15.54
Juncus balticus	74.29	21.70	16.12
Scirpus pungens	45.71	16.03	7.33
Glaux maritima	100.00	14.32	14.32
Carex praegracilis	22.86	6.14	1.40
Elaeagnus angustifolia	25.71	5.76	1.48
Eleocharis rostellata	51.43	4.77	2.45
Crepis runcinata	45.71	4.60	2.10
Hordeum jubatum	68.57	3.97	2.72
Carex aquatilis	14.29	3.81	0.54
Muhlenbergia asperifolia	31.43	3.76	1.18
Agrostis alba	31.43	3.52	1.11
Bromus tectorum	5.71	3.84	0.22

Fig. 2. Cluster diagram showing the relationships existent between 35 study sites where *Glaux maritima* was found growing. Relationships are based on species cover.

undation in the early season, the meadows are generally free of standing water by midsummer. Groundwater levels are most often at or near ground surface.

The Saline Meadow stands (Groups 2 and 3; Fig. 2) occur around the entire shoreline of the lake with the exception of the northwest corner. The soils in these meadows are seasonally wet and the communities are dominated mainly by *Distichlis spicata* (Table 2). Group 2 can be differentiated from Group 3 because of the high cover values of *Eleocharis palustris* and *Juncus balticus* in the vegetation. The presence of these two species indicates higher moisture levels in Group 2 than Group 3.

TABLE 2. Species encountered and the communities in which they occurred. Figures represent the mean cover in the groups (Fig. 1).

Species	Spike Rush	Saline Meadow 1	Saline Meadow 2	Sedge-grass	Marsh	Russian Olive	Inde-pendent
Actuca serriola	—	0.1	—	—	—	—	—
Agropyron intermedium	—	—	—	—	0.1	—	—
Agropyron repens	0.7	0.1	—	3.4	—	—	—
Agropyron riparium	—	0.1	—	0.1	—	—	—
Agropyron smithii	0.5	—	—	13.5	2.6	—	—
Agropyron subsecundum	—	—	—	—	—	53.9	—
Agrostis alba	1.6	1.1	—	12.70	3.8	—	—
Ambrosia artemisiifolia	0.3	1.3	3.3	8.2	5.6	1.3	0.1
Apocynum cannabinum	—	—	—	0.5	—	—	—
Asclepias incarnata	—	—	—	—	—	4.6	0.1
Asclepias speciosa	—	1.3	1.1	0.1	0.1	3.9	—
Asparagus officinalis	—	—	—	0.1	—	—	—
Aster brachyactis	1.1	—	—	—	—	—	—
Aster chilensis	0.6	5.8	4.9	8.0	1.3	—	—
Atriplex patula	—	1.3	0.2	—	1.3	1.3	—
Bidens frondosus	—	—	—	0.3	—	—	—
Bromus tectorum	—	—	—	—	—	45.1	22.1
Calamagrostis canadensis	—	1.2	—	3.3	—	—	—
Cardaria draba	—	—	—	—	—	43.6	—
Carex aquatilis	0.1	3.0	—	19.6	—	—	—
Carex aurea	—	—	—	0.1	—	—	—
Carex hoodii	—	0.1	—	—	—	—	—
Carex nebraskensis	—	0.4	—	0.5	0.7	—	—
Carex praegracilis	—	0.6	—	35.2	0.2	—	—
Carex rostrata	—	—	—	0.2	—	—	—
Castilleja linariaefolia	0.2	—	—	2.4	0.9	—	—
Castilleja minor	—	—	—	—	0.1	—	—
Centaurium exaltatum	0.1	—	—	0.1	—	—	—
Chenopodium album	—	—	—	0.3	—	—	—
Cirsium arvense	—	—	—	—	0.1	—	—
Cirsium undulatum	1.5	0.2	0.6	0.2	—	—	1.2
Cirsium utahense	—	—	—	—	—	24.2	—
Cordylanthus canescens	—	0.4	—	—	0.9	—	—
Crepis runcinata	0.4	1.1	11.25	16.8	1.0	—	—
Cressa truxillensis	—	—	—	—	—	—	4.1
Cyperus erythrorhizos	—	—	—	—	0.2	—	—
Descurainia sophia	—	—	—	—	—	—	0.1
Distichlis spicata	27.8	38.4	69.4	0.8	31.0	26.4	—
Elaeagnus angustifolia	0.1	0.1	—	—	0.2	99.99	—
Eleocharis palustris	65.6	16.0	0.2	13.5	1.3	—	1.5
Eleocharis rostellata	11.4	3.2	—	5.1	0.1	—	2.8
Equisetum hyemale	—	0.1	—	0.2	0.1	—	—
Equisetum kansanum	—	—	—	—	—	1.8	—
Erigeron lonchophyllus	0.1	—	—	—	—	—	—
Eupatorium maculatum	—	—	—	—	3.1	—	—
Festuca elatior	0.2	0.1	—	7.1	0.1	—	—
Glaux maritima	20.0	9.3	14.9	14.2	11.8	1.2	18.2
Glycyrrhiza lepidota	—	—	—	0.3	—	—	—
Grindelia squarrosa	—	—	—	—	—	0.1	—
Haplopappus lanceolatus	—	—	—	1.7	—	—	—
Helenium autumnale	—	1.2	—	—	—	—	—
Helianthus annuus	0.1	—	—	—	—	—	0.1
Hordeum brachyantherum	—	0.2	—	0.3	—	—	—
Hordeum jubatum	1.1	1.4	1.0	3.3	16.2	—	—
Iva axillaris	—	9.8	8.1	—	—	—	10.2
Juncus balticus	19.2	71.9	4.5	24.2	7.6	—	0.4
Juncus torreyi	—	—	—	—	0.1	—	—

Table 2 continued.

Species	Spike Rush	Saline Meadow 1	Saline Meadow 2	Sedge-Grass	Marsh	Russian Olive	Independent
Kochia scoparia	—	0.1	—	—	—	1.7	29.9
Koelaria cristata	—	0.6	—	—	—	—	—
Lactuca scariola	—	—	—	—	0.1	—	—
Lepidium montanum	—	—	—	—	—	—	3.6
Lepidium perfoliatum	—	—	0.4	—	—	0.1	0.1
Lycopus americanus	—	0.1	—	0.1	—	—	0.1
Lycopus lucidus	—	1.2	—	0.10	1.1	—	—
Medicago lupulina	—	0.2	—	—	—	—	—
Melilotus alba	—	0.2	—	3.9	—	6.9	—
Melilotus officinalis	—	—	—	0.3	—	—	—
Mentha arvensis	—	—	—	—	—	0.7	—
Muhlenbergia anserina	—	—	—	—	0.1	—	1.3
Muhlenbergia asperifolia	0.1	4.6	—	1.5	16.3	—	—
Panicum capillare	—	1.4	—	—	0.5	22.4	—
Panicum virgatum	1.8	—	—	0.2	—	—	—
Phlaris arundinacea	—	—	—	0.7	0.4	1.0	—
Plantago lanceolata	—	—	—	—	0.4	—	—
Plantago major	—	—	—	—	0.1	1.3	—
Poa nevadensis	—	0.8	—	—	—	—	1.0
Poa pratensis	—	0.5	—	0.1	—	—	—
Polygonum coccineum	1.1	—	—	—	—	—	—
Polygonum pennsylvanicum	0.1	—	—	0.2	0.1	1.2	—
Polygonum ramosissimum	0.1	—	—	—	—	—	0.4
Polypogon monspeliensis	0.1	2.5	—	—	—	—	0.7
Potentilla anserina	—	—	—	4.2	0.9	—	—
Potentilla gracilis	—	—	—	1.1	—	—	—
Puccinellia airoides	—	—	15.9	0.3	1.7	—	—
Ranunculus cymbalaria	0.9	—	0.1	3.3	1.1	—	—
Ranunculus testiculatus	—	0.1	—	—	—	—	1.3
Rumex crispus	—	0.2	—	—	—	—	—
Ruppia maritima	—	—	—	—	0.9	—	—
Salicornia rubra	—	0.2	—	—	—	—	—
Scirpus americanus	2.4	0.1	—	—	0.1	—	40.3
Scirpus pallidus	—	—	—	—	2.3	—	—
Scirpus pungens	1.0	0.4	0.4	7.1	67.6	50.0	—
Senecio hydrophyllus	—	1.0	—	1.9	—	—	—
Sisyrinchium halophilum	0.1	0.1	—	0.5	0.6	—	—
Sonchus asper	—	—	—	0.4	0.7	—	—
Sphenopholis obtusata	0.3	0.5	—	—	—	—	—
Sporobolus airoides	0.4	0.5	0.4	—	—	—	—
Suaeda depressa	—	—	4.9	—	—	—	—
Tamarix ramosissima	—	—	—	—	0.2	—	50.0
Taraxacum officinale	—	0.2	—	2.5	3.8	—	—
Tragopogon dubius	—	—	—	—	—	3.9	—
Trifolium pratense	—	—	0.3	2.0	17.5	—	—
Trifolium repens	—	—	—	20.1	0.1	—	—
Triglochin maritima	0.1	—	13.4	4.1	2.8	—	—
Verbena hastata	0.3	—	—	—	—	—	—
Veronica aquatica	—	—	—	—	—	—	3.8
Viguiera ciliata	—	5.1	—	—	—	—	—
Viola nephrophylla	—	12.2	—	—	—	—	—
Xanthocephalum sarothrae	—	—	—	—	—	—	0.8
Xanthium strumarium	0.1	—	—	—	—	—	0.1

The Russian olive communities (Group 6; Fig. 2) are scattered all around the lake but are found in small acreages. Russian olive is an introduced species that has invaded principally into the sedge-grass meadow areas. *Elaeagnus angustifolia* is the dominant overstory species, and the understory is dominated by *Scirpus pungens* and several weed species.

The grass-sedge meadows (Group 4; Fig. 2) are distributed around the lake on its north, east, and south boundaries but extend back from the marsh edge meadows toward higher and drier ground. These areas are seasonally saturated, but excess water generally has drained away by late spring. Groundwater levels are high all season in these areas. Sedges dominate the cover.

The differentiation of the cluster groups (Fig. 2) appears to be related to the moisture and salt tolerance relationships of the dominant species. All groups are either seasonally inundated part or all of the year or experience elevated levels of groundwater through the growing season. The moisture levels so close to the surface are due to ground water, springs, and seeps. The spikerush and marsh edge communities have consistently high water tables, whereas the other communities may experience lowered water tables late in summer.

The difference between the saline meadow groups (Groups 2 and 3; Fig. 2) is probably moisture and soluble salts related. Group 2 has lower salt levels and more moist soils and occupies the edge of the marsh. The stands in the group are dominated by *Distichlis spicata*, along with *Eleocharis palustris*, *Juncus balticus*, *Carex aquatilis*, and *Viola nephrophylla*. All of these species are associated with high levels of moisture in the soil. The Group 3 stands occupy a somewhat "drier", more saline habitat and are dominated by *Distichlis spicata*, *Pucinellia aeroides*, and *Triglochin maritima*. All are species adapted to the drier and more saline end of the gradient.

Sixteen soil factors were measured relative to the 35 stands studied. They are listed along with their mean and standard deviations in Table 3. The relation of these factors to the groups described in Figure 1 is shown in Table 4. Correlation analysis was conducted to assess any relationships between *Glaux maritima* cover and other habitat factors (Table 5).

An interesting relationship shown from correlation analysis is that between the grass and sedge life forms. They are negatively correlated ($p < .001$). As grass cover increases, sedge cover decreases. Several soil minerals are correlated to this relationship. Iron is positively correlated with sedges ($p < .05$), indicating that where sedge cover is high iron is also high. On the other hand, iron is negatively correlated with grasses ($p < .01$). Potassium shows an opposite pattern. Potassium is positively correlated with grasses ($p < .01$) and negatively correlated with sedges ($p < .05$). Magnesium ($p < .05$) and pH ($p < .01$) also show positive correlation to grasses, yet show no significant relationships with sedges. These relationships generally reflect the importance of a moisture gradient in vegetation patterns described above. Sedges occupy the wetter habitats.

Glaux maritima cover is uniformly distributed throughout the various groups (Fig. 2; Table 2), with the exception of the Russian olive communities. The Russian olive stands are in pastures that are subjected to irrigation throughout the growing season. The drastic decrease in *Glaux maritima* cover in the Russian olive stands was also shown in the correlation analysis, where *Glaux maritima* was negatively correlated to tree cover ($p < 0.1$).

Trees as a life form were positively correlated with potassium ($p < .05$) and phosphorus ($p < .01$). This relationship is also shown in Table 4, where the ppm for both these elements in the soil is somewhat higher in the Russian Olive communities. This

TABLE 3. Soil factors in sites where *Glaux maritima* is found growing, along with their means, standard deviations, and coefficients of variation.

Soil factor	Mean	Standard deviation	Coefficient of variation
P (ppm)	9.7514	6.05	0.6204
N (%)	0.33567	0.179	0.5333
Ca (ppm)	16392	20063	1.224
Mg (ppm)	1648.3	1051	0.6376
K (ppm)	554.81	406	0.7318
Na (ppm)	1252.8	891	0.7112
Fe (ppm)	57.712	54.5	0.9443
Mn (ppm)	36.820	143	3.884
Zn (ppm)	6.1794	9.81	1.588
Cu (ppm)	4.4754	2.41	0.5385
C (%)	9.9783	8.55	0.8569
Sand %	25.003	14.6	0.5839
Silt %	43.577	13.0	0.2983
Clay %	31.420	12.4	0.3947
pH	7.6134	0.386	0.5070
Soluble salts (ppm)	3008.3	2091	0.6951

TABLE 4. Relation of abiotic factors to groups in Figure 1. Numbers represent the means.

Soil factor	Spike Rush	Saline Meadow 1	Saline Meadow 2	Sedge-grass	Marsh	Russian Olive	Inde-pendent
P (ppm)	10.02	6.64	15.7	5.77	8.27	17.0	13.45
N (%)	0.389	0.265	0.323	0.37	0.303	0.239	0.370
Ca (ppm)	29915.0	10585.0	11872.0	10967.0	9479.0	7692.0	10399.0
Mg (ppm)	1275.6	1437.513565	2045.8	2566.7	1828.0	700.5	
K (ppm)	484.9	536.5	831.5	130.0	669.3	1132.0	750.5
Na (ppm)	1620.7	1194.2	1430.25	573.17	1186.17	391.5	1055.0
Fe (ppm)	67.85	65.74	21.35106	36.83	24.15	63.7	
Mn (ppm)	92.98	10.696	12.848	16.273	15.317	10.1	22.1
Zn (ppm)	8.492	8.532	1.62	6.217	4.743	3.23	5.0
Cu (ppm)	3.662	4.272	5.02	6.74	3.24	4.19	5.16
C (%)	15.762	6.224	12.678	4.867	6.597	10.95	9.28
Sand (%)	20.52	12.8	22.725	37.333	27.67	30.0	32.50
Silt (%)	41.50	51.2	45.55	36.67	40.67	41.5	57.5
Clay (%)	36.98	36.0	31.725	26.4	31.67	28.5	10.0
pH	7.542	7.12	7.86	7.63	7.797	8.0	7.70
Soluble salts (ppm)	3279.0	3250.0	5720.0	1264.0	2905.0	1905.0	2270.0

would undoubtedly reflect the use of commercial fertilizers on the pastures.

The cover of *Glaux maritima* was found to be positively correlated to parts per million sodium and soluble salts in the soil ($p < .05$). This finding is in agreement with those in other studies (Rozema 1975 and Rozema et al. 1978). These positive correlations indicate that as soil salts increase *Glaux maritima* cover also increases. *Glaux maritima* is known to be a halophyte (Adam 1977) and would therefore be expected to do well in sites with elevated levels of salt in the soil.

No other factors correlated significantly with *Glaux maritima* and its cover in central Utah, even though there was considerable variation in its occurrence from stand to stand. The lack of further correlations with biotic and abiotic parameters in its environment would indicate a wide tolerance in terms of habitat variability, since all factors measured showed coefficients of variation near 50% (Table 3).

Of paramount importance in the ecology of *Glaux maritima* would be moisture and salt levels in the soil. As before stated, all sites where this species occurred in any degree of importance also had high moisture levels throughout the growing season — this coming from springs, seeps, elevated water tables, and early spring runoff. Many areas are seasonally inundated. It appears that this plant is narrowly adapted to moisture conditions in its habitat. Either too much or too little water in the habitat tends to restrict its distribution. However, with its moisture requirements met and having a high tolerance for variability in other habitat factors, the relationships of this species to increasing salinity in its environment is more easily understood. As salts in the system increase, many species are not able to grow (Fig. 3), so halophytic species will have a competitive edge. Also, since many of the species in its habitat reproduce asexually, often forming large clones (Brotherson and Everson 1982), *Glaux maritima* could invade in areas where there are openings and thus compete with fewer species. This is well demonstrated in Figure 3, where concentrations of salt exceeding 2500 ppm show a corresponding 50% decline in number of species encountered in the sampling quadrats and the cover values of *Glaux maritima* show a corresponding 50% increase.

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TABLE 5. Results of correlation analyses between factors (biotic and abiotic) associated with sites where *Glaux maritima* was found growing.

Variable	Positive correlations	Negative correlations
BIOTIC FACTORS		
Glaux maritima (cover)	Na (.05) soluble salts (.05)	
Trees (cover)	ppm P (.05) ppm K (.01)	sedges (.05)
Grasses (cover)	ppm Mg (.05) ppm K (.01) pH (.01)	ppm Fe (.01) sedges (.001)
Forbs (cover)	sedges (.01)	
Sedges (cover)	ppm Fe (.05)	ppm K (.05) trees (.05) grasses (.001) forbs (.01)
Monocots (cover)		ppm P (.05) % C (.05) pH (.01)
ABIOTIC FACTORS		
P (ppm)	% C (.05) trees (.05)	monocots (.05)
Ca (ppm)	% C (.001)	
Mg (ppm)	grasses (.05)	% C (.05)
K (ppm)	pH (.05) trees (.01) grasses (.01)	ppm Fe (.001) sedges (.05)
Na (ppm)	soluble salts (.001) Glaux maritima (.05)	
Fe (ppm)	ppm Mn (.05) ppm Zn (.01) ppm Cu (.01) Sedges (.05)	ppm K (.001) pH (.05) soluble salts (.05) grasses (.01)
Mn (ppm)	ppm Fe (.05)	
Zn (ppm)	ppm Fe (.01) ppm Cu (.05)	
Cu (ppm)	ppm Fe (.01) ppm Zn (.05)	
C (%)	ppm P (.05).M ppm Mg (.05) ppm Ca (.001) soluble salts (.05)	monocots (.05
Sand (%)		% silt (.001) % clay (.001)
Clay (%)		% sand (.001) % silt (.05)
pH	ppm K (.05) trees (.01)	ppm Fe (.05) monocots (.01)
Soluble salts (ppm)	ppm Na (.001) % C (.05) Glaux maritima (.05)	ppm Fe (.05)

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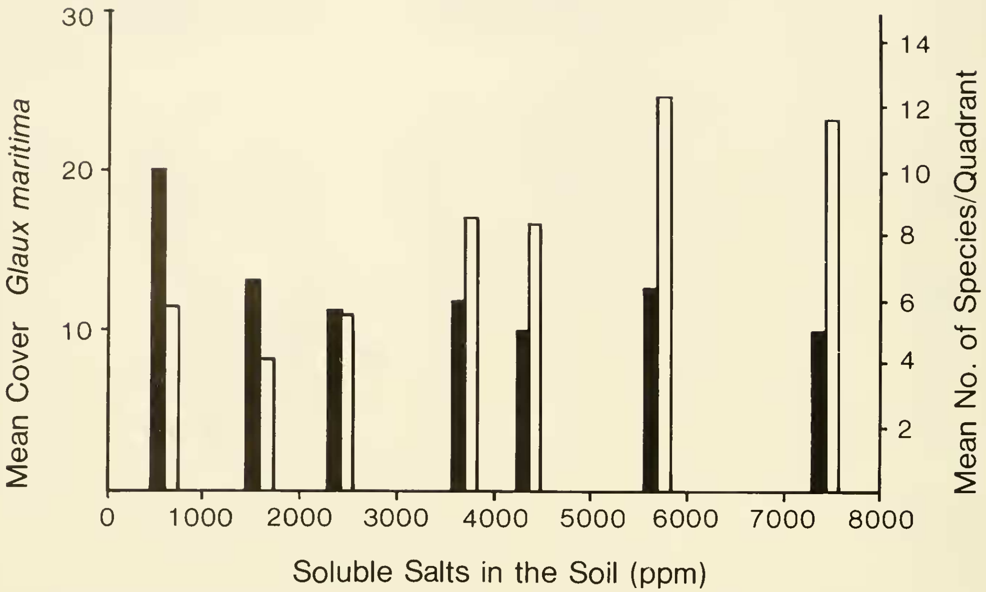

Fig. 3. Historgram showing the relationships between *Glaux maritima* cover, average number of species per quadrat, and parts per million salt in the soil. Dark bars represent average number of species per quadrat and clear bars represent *Glaux maritima* cover.

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